e-Commerce Solutions for Supply Chain Management: A Comparative Review

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ABSTRACT

Supply chain management (SCM) has recently attracted significant interests from academics and industry. Along with the growing concern of implementing **supply chain management** in many enterprises, there has been a proliferation of two kinds of software solutions, business-to-business (B2B) and **supply chain management** (SCM), which aim at improving the performance of **supply chain**. The first part of this article reviewed some literatures related to three core processes in **supply chain**: product design and development, **supply chain** planning and order life cycle. The second part of this article presented a comparison of these software solutions based on the functionality offered by three leading vendors in each kind of solutions. The emphasis of each kind of solution is contrasted and some area are identified for future development. The results of the

comparisons indicate several research directions in the field of **supply chain management**.

1. INTRODUCTION

Global competition has been fierce than ever. Manufacturers find themselves in a very competitive environment in which they are expected to offer a variety of products and delivery them in a much shorter lead time. In order to survive in this competitive market,

they have to move from a traditional "standalone" business model to a "network" business model. "Network" means that companies have to collaborate with each other to seek greater benefit in doing business instead of being a "standalone" player. It has been believed that the network business model can be realized through the implementation of **supply chain management** (Christopher,1992).

The advent of Internet significantly promotes the realization of **supply chain management** as it provides a cost-effective tool to integrate different business players and facilitate the collaboration between them (Aberdeen, 2000). It has been reported that the software market of **supply chain** solution is expected to expand at a compound annual growth rate of almost 50 percent and reach an estimated total value in excess of $18 billion by 2003 (Cherry Tree, 2000). AMR Research (Bermudez, 2000) projects that

Business-to-Business (B2B) commerce will reach $5.71 by the end of 2004, or 29% of the dollar value of commercial transactions. The proliferation of B2B marketplace and **supply chain management** (SCM) software package has shown the impact of Internet on the transformation of business model.

Supply chain management has been studied extensively for many years. Thomas and Griffin (1996) classified **supply chain** coordination into buyer-vendor, production-distribution and inventory-distribution. Vidal and Goetschalckx (1997) extended the review of strategic production-distribution models. Several representative models in previous researches were compared and reviewed. It has been seen that, however, most of the research related to **supply chain** modeling, planning and optimization are focused on strategic issues. There has been few research that addresses the impact of commercial SCM package and B2B commerce on **supply chain** practice. As suggested by Erenguc et

al. (1999), commercial software package like ERP should be used to support academic research. It is therefore imperative that researchers in SCM should understand the extent of functionality of SCM and B2B solutions so that the research output would be more realistic and applicable. The aim of this report is to review and discuss various issues of B2B commerce and **supply chain** solutions in order to provide insights for future research in SCM.

The methodology in this report is based on review and comparison of the state-of-the-art B2B marketplace and SCM software vendor. The comparison basically focuses on functionality offered by different vendors. The definition and scope of SCM from various literatures will be discussed in Section 2. The work from previous researches will be addressed. Three core processes are identified in **supply chain**. In Section 3 and 4, the B2B solution and SCM solution offered by 3 vendors will be introduced respectively. Some key points in the comparison will be analyzed in more detail in Section 5. The analysis will also highlight some research directions for future study.

2. LITERATURE REVIEW

2.1 Definition of SCM

In this section, we will review the definition of SCM and identify the major activities in **supply chain**. There have been a lot of literatures which discuss the definition of SCM in different perspectives. Christopher (1992) offered four aspects that differentiate SCM from traditional production **management**:

1. **supply chain** is a single entity rather than fragmented,
2. SCM calls for strategic decision making that reducing overall costs is the shared objective,
3. view inventory as balancing mechanism of last, not first resort,
4. emphases integration of information systems in a distributed sense,

Lee et al. (1993) and Davis et al. (**1999**) defined **supply chain** as a network of facilities that performs procurement, production and distribution to meet the requirement of customer. Tan (2001) discussed the convergence of two aspects: procurement (supplies and purchasing) and distribution (transportation and logistics) of previous literatures. All of the authors emphasize that integration and coordination are essential to successful SCM. Lee (2000) discussed in detail how integration creates value in **supply chain**. There has been a plenty of researches which address the issue of strategic planning and optimization analytically in SCM (Thomas et al., 1996; Vidal et al., 1997; Erenguc et al.,**1999**). A lot of analytical models have been established to minimize the total costs in various aspects (procurement, production and distribution) of **supply chain**. Majority of the models aims at minimizing the inventory cost which serves as a common objective in

the **supply chain**. The importance of integrated information system to SCM was discussed by several authors in relation to specific research projects (Hirsh et al., 1995; Zhou et al., 1999; Shaw, 2000). These authors described various research projects which are dedicated to the integration and coordination of distributed production information system in **supply chain**. Holland (1995) conducted a case study of the impact of interorganizational information systems (IOSs) in textile industry. It has been shown that coordination with IOSs in **supply chain** can improve the response to market changes and quality of product. Graham et al. (2000) concluded that Internet has a positive impact on promoting **supply chain** integration. The authors described it as a key element to drive innovation and create more values in business. Viswanadham (2000) analyzed 3 core business processes of manufacturing enterprise: Product design process, order-to-delivery process and **supply chain** process. In this review, 3 similar core processes are identified to analyze the **supply chain**: Product design and development, **supply chain** planning and order life cycle. The definition of each process and their inter-relationship will be discussed in this section.

2.2 Product design and development

Product design and development process aims at delivery a design of product which conforms to the specification of customer. The design does not merely include functional

and aesthetic aspect. It also includes the method of production and related logistics arrangement through which the product can be delivered to customer. In the **supply chain** context, such concurrent approach to product design and development encourages collaboration of **supply chain** partners (Anumba et al., 2000). One of the examples of

such collaboration is supplier involvement in new product development (Huang and Mak, 2000). Holland (1995) has shown that **supply chain** collaboration with interorganizational information systems (IOSs) can improve responsiveness and quality of product design. McIvor et al. (2000) discussed the impact of electronic commerce on buyer-supplier relationship. The authors argued that e-commerce actually reengineers the interface between buyer and supplier. This was illustrated by case studies in which supplier and distributor sourcing, new product introduction and order transactions are being transformed to be more efficient and effective. It has been suggested that inter-organizational processes in **supply chain** can be leveraged by employing information technologies. Huang and Mak (2000) developed a methodology for modeling supplier-customer interface in SCM. Customer can post the requirement of a part, which is used to make a product, as a contract to seek proposal from suppliers. Suppliers can submit their capability of producing the part through the Internet. The model also provides an

evaluation mechanism for the suppliers' bid. Customer can then select the best supplier for each purchasing part and establish the product's **supply chain** accordingly. A prototype which employs the web-based technology has been developed to implement the model (Huang et al., 1999). Implementation and deployment technology were discussed. The success of implementing such a web-based system, however is constrained by reliability, security of the network and data processing speed.

Taylor (1997) considered production site capacity and capability in DFMA for global application. The research explicitly accounted for production capacity of global site by developing a model with an objective to minimize the total costs which are incurred in production, design, logistics, inventory, setup, tooling and procurement of

equipment. The model is formulated as a mixed-integer linear program (MILP) which determines production site for each alternative process of a new product. This research, however, studied only one product design problem. The model is inadequate to represent a global **supply chain** in which a new product is produced through several inter-dependent processes that canbe performed in different locations. Garg (1999) integrated product and processes design in **supply chain**. A model has been developed to perform tradeoff analysis on inventory level, service rate, location capacity and production capability when designing product and processes in **supply chain**. The author integrated

an inventory network sub-model, which describes the **supply chain** configuration, and a queuing network sub-model, which describes the production dynamics in production site. The model highlighted the importance of packaging design at the early stage of product and process design cycle. It should be noted that the model requires many stochastic data that may not be possible to be collected in practice, especially for new product. Graves and Willems (2000b) addressed how to select alternatives for new product's **supply chain**. The alternatives include sources for material, production processes and transportation means to deliver product to customer. A dynamic programming model was developed to select anoption of each stage so as to minimize the cost of goods sold, safety stock cost and pipeline stock cost. The options required by the new product in each stage of **supply chain**, however, must be pre-determined before applying the optimization model.

Many strategic models related to product and process design in **supply chain** have not considered the qualitative issue of supplier (e.g. friendliness with the suppliers, social and political factors). These factors have to be considered in the models in order to put

into practice (Vidal and Goetschalckx, 1997). These researches can be considered as the integration of product design and production planning.

2.3 Supply chain planning

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After defining the product's function and process characteristics, one can start the planning processes. The objective of **supply chain** planning is to satisfy the demand from customer by specifying "when to do what" in **supply chain**. The **supply chain** planning also specifies the allocation of **supply chain** resources (e.g. materials, labors, machines, production sites etc.). Other objectives of **supply chain** planning include minimizing inventory cost, utilizing **supply chain** resources and reducing order lead time. Shepherd and Lapide (1999) discussed 3 hierarchical levels of **supply chain** planning, namely, strategic, tactical and operational. The three levels of planning differ in frequency of planning and planning time horizon. The frequency of planning increases from strategic, tactical to operational while the planning time horizon decreases from strategic, tactical to operational. The objective and problem size of each level of planning are different. The literatures in each level of planned will be reviewed in this section.

Strategic **supply chain** planning aims at determining the configuration and operational parameters of **supply chain**. The configuration is described by location of plant and distribution center, flow of materials, and choice of transportation mode, etc. The operational parameters include safety stock in each location, product mix, production and service rate, and reorder policy, etc. Strategic planning is usually done for every one or two year. In this level of planning, it is assumed that product design has already been done but it can be part of product design process as discussed before. There are a number of academic researches that represent a typical problem in this level. Graves et al. (1998)

modeled a multi-stage system by using a single stage model as building block. The authors shown how to analyze the tradeoff betweenproduction capacity and inventory level and apply the model in a DRP (distribution requirement planning) problem of a company. The model, however, highly simplifies the production process as pointed by the authors. It cannot support a general product structure or BOM with several levels. The authors also assumed stationary demand, full service guarantee and constant lead time. Lee and Billington (1993) studied decentralized **supply chain** problem to optimize safety stock subject to target service rate. A model was developed to analyze the dynamic between service level and safety stock. This model was applied in a printer manufacturer successfully. The model requires a lot of stochastic data that may be a barrier to the application of the model.

Inderfurth and Minner (1998) developed an optimization model to determine the safety stock level in each inventory location in **supply chain** with an objective to minimize inventory holding cost. Different **supply chain** configurations were studied and optimal policy was derived for each case. Graves and Willems (2000a) developed a stochastic model for requirement planning in **supply chain**. The model determines the service times of each node in **supply chain** in order to minimize the expected safety stock. A number of assumptions were made in this study including deterministic lead time, constant demand, same review period and infinite capacity constraint. Sabri and Beamon (2000) developed a model that determines the **supply chain** configuration (e.g. flow of goods, choice of plant and distribution center) and operational parameters (e.g. safety

goods, choice of plant and distribution center) and operational parameters (e.g. safety

stock, service level, ordering policy). The model also incorporates stochastic factors in supply chain. It serves as a tool to aid supply chain design and analysis of

competitiveness of **supply chain**. Again, as the model encompasses the whole **supply chain**, data collection is a problem in practice, especially for the stochastic factors. After doing strategic planning, the **supply chain** partners are determined. They can start coordination of operation in a shorter planning horizon i.e. tactical planning.

Tactical planning concerns the matching of **supply** and demand based on demand forecast and actual order from customer. Demand forecast is a major input in this stage. In SCM, customer is encouraged to share its demand plan to supplier so that the supplier can generate a production that can fulfill the demand optimally. It is the basic goal in collaborative forecasting in **supply chain** (Helms et al., 2000). The planning process then generates a requirement plan, according to the forecast and actual demand, which specifies demand of each item and a **supply** plan which specifies the source of **supply**, i.e. make or buy, of each item. Capacity plan is also generated to show loading of production site within the planning horizon. Traditionally, in a single plant situation, this task is handled by MRPII (Manufacturing Resource Planning) (Vollmann et al., 1992). When tactical planning is considered in **supply chain** context, limitations of MRPII

methodology lend itself as an ineffective tool of **supply chain** planning. Due to limited space of this article, these limitations will not be discussed in this section.

Operational planning is a more detail scheduling in each production plant based on the tactical planning in a shorter time horizon. Tactical planning determines the production order for each product in each planning period. These orders have to be sequenced and scheduled within a much shorter timer frame, e.g. a day or a week, under operational planning. Pinedo and Chao (1999) have presented an overview of operational scheduling. One of the common research problems in this area is job shop scheduling. At

this level of planning, production sequence and resource allocation are determined precisely to optimize some objectives e.g. tardiness, average flow time etc. In the light of SCM, operational planning should be processed in order to fulfill the requirement of **supply** plan. It should be responsive to changes that are induced by other partners in the **supply chain**. There is, however few research that addresses this issue. Rapid response and adaptation to changes are the logical evolution of **supply chain management** (Metz, 1998). The importance of a responsive plan to **supply chain** will be discussed in later section.

It is clear that there has a lot of research that contributes to strategic level of planning in **supply chain management**. One can understand that, from the above

literatures, strategic planning is usually done for new production introduction. This is a point the really integrate the product design process (PDP) and **supply chain** planning process (SCP). As cited above, there are, however, several limitations of strategic planning in **supply chain**. Data collection is quite difficult for some models which require a large amount of stochastic data. Those planning models are done at an aggregate level of product, time period and resource For example, products in the same family are grouped together as a single product unit. The aggregated model is a simplified model of reality and, therefore, the way of doing aggregation would affect the feasibility of the planning results (Graves, 1999). There is, however, inadequate research addressing the problems of tactical and operational planning in **supply chain**. On the other hand, in the field of production planning and control (PPC), tactical and operational planning has been extensively studied. Various models like aggregate production planning, MRP and job shop scheduling have been proposed to solve planning problems in tactical and

operational level respectively. It is a logical move that this research will consider to modify the application of these models in PPC so that they can be employed in SCM. This point is also supported by Erenguc et al.(1999) who suggested that extension of traditional work in a single facility to a broader **supply chain** is one of the future

directions in SCM research. Basically the one of the major differentiations between PPC and SCM is the scope of problem domain. The scope of PPC models is always a single plant or a work center while the scope of SCM models includes customer, supplier and manufacturer. When dealing with problems like inventory, capacity or scheduling in **supply chain**, one has to consider the behavior of suppliers and customers and incorporate them into the planning model. After a plan is produced, the next process is to execute the plan in order to achieve the requirement from customers. The dynamic of this process will be discussed in the next section.

2.4 Order Life Cycle

In **supply chain** the most common medium that represents the operational relationship between buyer and seller is an order. There are generally three types of order: customer order, production order and purchase order. The interaction and dynamics of these orders, i.e. order life cycle (OLC), represent the execution of the **supply chain** plan, i.e. the actual conversion process of materials to final product, and the logistics coordination of supplier, manufacturer, sub-contractor, distributor and customer. This process is similar to the order-to-delivery process (ODP) described in Viswanadham (2000). The focus of ODP is material flow or logistics between buyer and seller while the focus of OLC is, however, the dynamics of orders. In **supply chain** customer is the key driver of the core processes. A customer would place a customer order or sales order to specify the details

(e.g. product specification, order quantity, due date, price etc.) of its demand. When a company receives that order, it would perform *tactical planning* to generate a **supply** plan which consists of production orders and purchase orders. Production order specifies the details (e.g. lot size, required material, tooling requirement) of an item which would be produced. Purchase order specifies the details (e.g. quantity, supplier) of a part which would be purchased from its suppliers. After receiving materials from the suppliers, the company would execute the production order according to a schedule which is generated from *operational planning*. The company would then deliver the product to the customer after completion of production to fulfill the customer order. It is obvious that the 3 types of order are highly interrelated. A change in one type of order certainly triggers a change to other orders. In order to make the order life cycle more efficient, coordination is a key issue in this respect. Hence, the **supply chain** can be interpreted as an "order **chain**" where different orders represent and link the operation of different **supply chain** partner.

There are obviously two flows in the above order life cycle: information flow and material flow. Both of the flows are controlled by the orders. The order also serves as a medium that integrates the **supply chain** planning process and order life cycle process. Information generated by planning is represented in the order on which **supply chain** execution is based. Apart from the information flow and material flow, the order life cycle also consists of cash flow. The cash flow is realized by a transaction between customer and supplier. In relation to customer order and purchase order, the customer receives the product and pay to its supplier. The order life cycle, therefore, represents the flow of information, material and cash.

The dynamic aspect of order life cycle is represented by unexpected change of orders in an uncertain environment. These changes include order volume, product specification, machine breakdown, materials delay, order cancellation etc. Flexibility of the **supply chain** to response to the changes is a competitive edge in today marketplace (Correa, 1994). There are two approaches to deal with unexpected change in the literatures.

One approach is to plan for the changes during **supply chain** design. This can be done in strategic level of planning as discussed in previous section. Correa (1994) has identified several strategic techniques to deal with unexpected changes including vertical integration, preventive maintenance, supplier development, forecasting etc. Helo (2000), by simulation studies, concluded that capacity utilization is a significant factor to achieve responsive or agile **supply chain**. The author suggested that capacity hedging is an effective way to against market uncertainty. This method is supported by simulation experiments which were conducted by Yellig and Mackulak (1997). Kusiak and He (1998) have proposed four rules for the design of agile manufacturing systems in terms of plant structure and product features. The basic principle of the rules is to simplify the complexity of scheduling. The rules can potentially be implemented in **supply chain**

design if one regards a manufacturing system as a **supply chain**. Griffiths and Margetts (2000) concluded, from a case study, that supplier development, coordination and communication facilitate the responsiveness and reduction of undesirable variations in **supply chain**.

Another approach to deal with unexpected changes is production rescheduling. This approach is executed in a real-time manner through the change of production order.

Rescheduling is performed based on the initial schedule generated by operational planning. The responsiveness of a schedule is called robustness. Leon et al. (1994) proposed a performance measure of robustness of a schedule. Shafaei and Brunn (1999a, 1999b) identified scheduling rule, SPT-C/R, with frequent rescheduling as an effective mean to tackle variations (e.g. machine breakdown, lead time uncertainty) in a job shop. The authors also shown that bottleneck or unbalanced work load is detrimental to the robustness of a schedule. An integrated framework of job releasing, **routing** and scheduling has been proposed to generate a robust predictive schedule (Shafaei and Brunn, 2000). The authors attempted to integrate tactical and operational level of planning to cope with the dynamic nature of the shop floor by using a rolling time horizon approach. The application of rolling time horizon in dynamic scheduling problem has been studied by Muhlemann et al. (1982), and Sun and Lin (1994). Shafaei and Brunn

(2000) modeled the job releasing and routing problem as an integer programming model and employed the SPT-C/R heuristic to solve the scheduling problem. This framework, however, does not consider the BOM of a product. There is no precedence constraint between the jobs. This constraint may be violated after scheduling. More importantly, the framework does not suggest any rescheduling method based on the robust predictive schedule. There is certainly a limitation when a variation, which is out of the expected variation in the simulation study, occurs so that the schedule cannot accommodate such change. As reported by Euwe et al. (1998), rescheduling is seldom used in industry. This function has even not been well designed in commercial MRP package.

It is, therefore, necessary to investigate the rescheduling decision due to some variation that cannot be tackle by predictive schedule. Grubbstrom and Tang (2000)

studied the tradeoff between different rescheduling decisions. A single-level production system for rescheduling has been modeled. The model supports rescheduling decision making at one point of time in planning horizon. Li et al. (2000) has developed a rescheduling expert simulation system to help manager make rescheduling decision. The simulation model takes input data of production order (e.g. job types, processing time, routing, due date etc.) manually. Several performance measures (e.g. mean flow time, job

queue length, tardiness etc.) of the schedule are given by the simulation. Four types of unexpected variation or disturbance have been identified: incorrect work, machine breakdown, re-work and rush orders. Manager can decide whether the schedule needs to be rescheduled due to disturbances. The expert system provides support for manager to perform rescheduling.

Guo and Nonaka (1999) have proposed a method to particularly target rescheduling problem when machine failure occurs. The proposed method indicates when to perform rescheduling based on the degree of disturbance, i.e. machine breakdown. The rescheduling method attempts to minimize the makespan of all jobs. Sabuncuoglu and Bayiz (2000) studied the rescheduling problems under different shop loading conditions (balanced and bottleneck) and different methods of scheduling (optimization and heuristics). The authors concluded that system performance (i.e. makespan) is more adversely affected by bottleneck shop loading condition rather than large system size. Another finding indicated that on-line heuristic method outperforms off-line optimization method when there is unexpected disturbance. Jain and Elmaraghy (1997) firstly employed genetic algorithm to generate a near-optimal schedule, and then developed a rescheduling algorithm for a flexible manufacturing system (FMS). The authors studied

disturbances caused by machine breakdown, increased order priority, rush order arrival

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and order cancellation.

To summarize, order life cycle is a realization of **supply chain** execution. The dynamic or stochastic nature of **supply chain** leads to unexpected variations or changes when compared to **supply chain** planning. There have been two approaches to deal with such unexpected changes in **supply chain**: planning and rescheduling. The planning approach tries to generate a robust plan or schedule that can accommodate the stochastic disturbances while the rescheduling approach tries to adapt to that disturbances based on the original schedule. Various studies have shown that existence of bottleneck in shop floor is detrimental to the robustness of the schedule. It has been found that the heuristic rescheduling is better to cope with stochastic disturbance than the optimization planning. All of the above rescheduling researches, however, solely focus the scope in shop floor. There has been no literature that discusses the model and methodology of rescheduling in **supply chain**. Since production order, which is the main study object in all rescheduling literatures, is closely interrelated to purchase order and customer order in **supply chain**, the customer and supplier conditions should be considered in rescheduling problem. The competitiveness of **supply chain** is enhanced by the effective way of dealing with stochastic disturbances in order life cycle.

Recent advancement of information technology (IT) facilitates the automation and execution in order life cycle. One of the significant contribution of IT to **supply chain management** is the emergence of business-to-business (B2B) commerce or e-commerce. Reynolds (2000) reviewed the recent development and application of e-commerce in **supply chain**. de Souza et al. (2000) illustrated, through a simulation study, that close

coordination between **supply chain** partners can reduce undesirable variations (e.g. order backlogs) in **supply chain**. A decentralized coordination model has been proposed to enhance the coordination between buyer and seller by using a market mechanism. Some coordination standard of e-commerce like Open Buying on the Internet (OBI) has been developed in industry to augment the purchasing process (Tian et al., 1999). Close coordination can also be fostered by inter-organizational workflow technology. van der Aalst (1999) discussed and reviewed different workflow architectures for e-commerce. E-commerce has been a very active research topic while the deployment of B2B marketplace solution is proliferating in industry. It is observed that many enterprises adopt B2B solution to automate and streamline some of the business processes (e.g. procurement). This indicates an opportunity of deploying IT to optimize the order life cycle. In the next section, a review and comparison of several commercial B2B solution providers will be presented. The functionality of 3 selected vendors will be analyzed and compared.

3. B2B MARKETPLACE SOLUTION

In this section, the general business model of B2B marketplace will be introduced. Three B2B marketplace solution vendors are selected for comparison. The key features of each solution is highlighted in Appendix A1. The comparison will be followed by a discussion which focuses on the future development.

Business-to-Business (B2B) commerce has been growing around the world. It has been estimated that B2B commerce will reach \$5.7T by the end of 2004, or 29% of the dollar value of commercial transactions (Bermudez, 2000). There are many vendors who offer B2B marketplace solution that facilitates the enterprise to reap the benefits of conducting business on the Internet. B2B marketplace can be defined as "Neutral Internet-based intermediaries that focus on specific industry verticals or specific business processes, host electronic marketplaces, and use various market-making mechanisms to mediate any-to-any transactions among businesses" (Kaplan & Sawhney, Taxonomy of B2B Hubs??). There are basically three parties involved in B2B activities, namelv

marketplace maker, buyer and seller. A marketplace maker hosts a B2B web site on which a buyer and a seller process a transaction. The business model is justified on making revenue by transaction fees for matching buyer and seller. It provides service to buyers such that the buyers can source their product from many sellers. On the other hand, sellers can publish their product information in the marketplace so that buyers can search and order them on the web.

The business model of B2B marketplace can be classified in two dimensions: vertical/horizontal and public/private. Vertical marketplaces focus on the needs of a particular industry, so they are typically set up along traditional industry segments such

as Automotive, High Tech, Consumer Goods and Metals. Horizontal marketplaces typically focus on specific business processes that are either generic to many vertical markets, like indirect materials procurement, or span multiple business processes or vertical markets such as logistics and service assets **management**. Public marketplaces contain multiple suppliers and multiple buyers (many-to-many). It is a neutral intermediary where no particular supplier or buyer owns or controls the market. Private marketplaces represent a "one-to-many" marketplace. It can be one-buyer-to-many-suppliers or one-supplier-to-many-buyers. In either case the marketplace can be thought

of as private or biased towards "one" buyer or supplier. Some examples are General Electric (GE) and Warl-Mart. The B2B solution vendors selected in this section provide all types of B2B marketplace. Table 1 presents the results of functionality comparison. The explanation of functionality in Table 1 can be referred to Appendix A2.

Table 1

Comparison of B2B solutions

Functionality	*CommerceOne* [1]	*Ariba* [2]	*TradeMatr*
Industry			
Aerospace	X		X
Construction	X		
Discrete Manufacturing	X	X	X
Education	X	X	
Energy	X	X	X
Financial Service	X	X	

Food	X		
Healthcare	X		
High Technology	X	X	X
Hospitality	X		
Entertainment	X		
Life Science	X		
Process Manufacturing	X		X
Pharmaceutical		X	
Retail	X		X
Telecommunication		X	
Transportation		X	X
Utility		X	X

Product Design and Development

Collaborative conceptual design

Share design data on the web

Design optimization

Support early supplier

involvement

Workflow enabling design

Page

process			
Supply Chain Planning			
Supply chain design and			
modeling			
Strategic optimization of **supply**			
network			
Distribution and logistics			
planning			
Collaborative demand			
planning/forecasting			
Constraint-based			
planning/scheduling			
"What-if" simulation capability			
Graphical operational scheduling			
Order Life Cycle			
Available-to-Promise			X
Capable-to-Promise			
Order configuration	X*	X*	X
Order tracking	X*	X*	X
Manufacturing execution			
Reactive planning/scheduling			

Delivery control

Buyer Solution

Global sourcing	X	X	X
Request for quotation	X	X	X
Procurement automation	X	X	X
Supplier Solution			
Content management	X	X	X
Dynamic pricing	X	X	X
Connect to other marketplaces	X	X	X
Marketplace Maker Solution			
Setup vertical marketplace	X	X	X
Connect to other marketplaces	X	X	X
Business Services			
Auction	X	X	
Fulfillment service	X		X
Financial transaction	X	X	X
Analytics			

Sales			X
Procurement			X
Order fulfillment			X
Finance			
Integration with ERP	X	X	X
User Interface	Web-based	Web-based	Web-bas

1. CommerceOne (2000a, 2000b, 2000c)

2. Ariba (2000a, 2000b)

3. i2 (2000a – f)

* These features are enabled by integrating with third-party ERP and SCM solution.

The 3 vendors provide competing features for buyers, sellers and marketplace makers. They also offer electronic business services to automate the traditional one like financial settlement. It is obvious that product design and **supply chain** planning functions have not been implemented in B2B marketplace extensively. One of the major reasons is that these processes involve a large amount of data transfer through the Internet. Network reliability and security and data consistency between different trading partners would be a barrier

that hinders the move to such level of collaboration. As discussed in literature review of **supply chain** planning, most of the planning models require a lot of input data from all the **supply chain** partners. The matter is more serious if the B2B participants consider these data as commercially sensitive and confidential so that they really do not want to send these data out of their firewall. As long as all trading partners in B2B marketplace commit to **supply chain management,** i.e. share a common goal to optimize the **supply chain,** and change their status to "**supply chain** partner", the collaborative product design and **supply chain** planning process can be realized. It seems that such collaborative **supply chain** processes would probably, and more easily, be implemented in the vertical/private marketplace. In such type of marketplace, a large enterprise, which is the host of that marketplace, has dominant role to collect data from its suppliers or customers. The security issue would be less sensitive in this case since agreement has

already been established with the suppliers or customers. SCM concepts can, therefore, be easily implemented.

Regarding to the product design and development process, there has been little effort of integrating such process in B2B marketplace. The major reason is the complexity of product data. Since the network bandwidth is limited, transferring a large

data file like CAD model is inefficient and unreliable. Some activities in product design process, however, can be facilitated by Internet and integrated to B2B platform despite the bandwidth limitation. One of them is early supplier involvement in new product introduction (Huang and Mak, 2000). The authors developed a practical, web-based model to facilitate collaborative product design between suppliers and manufacturer.

Another potential development in B2B marketplace is the analytic of **supply chain** data. Since there will be many transactions conducted in the marketplace, the market maker can collect a lot of data for performance analysis. Proper usage of the result can lead to improvement in **supply chain**. Since the features of present B2B vendors are very similar, one of the ways to enhance the functionality is to provide product design process and **supply chain** planning process with existing marketplace. Some B2B marketplaces have integrated to SCM solution to sharpen their competitiveness (McCullough et al., 2000). Kafka et al. (2000) concluded that B2B marketplaces have to incorporate **supply chain** planning capability into their existing services in order to survive. In the next section, a comparison of three SCM solution vendors will be presented.

4. SUPPLY CHAIN MANAGEMENT SOLUTION

This section focuses on the functionality of **supply chain** package developed by SAP, Baan and i2 Technology. Due to limited space, the scope of this comparison is limited to 3 software vendors who offer solution in **supply chain management**. Most of the SCM solutions focus on the planning capability. They aims at providing an optimized plan in **supply chain**. A description of functionality of each vendor is presented in Appendix A3. The comparison of **supply chain management** solution from SAP, Baan and i2 is presented in Table 2. The explanation of functionality in Table 2 can be found in Appendix A4.

Table 2

Comparison of SCM solutions

Functionality	**SAP APO** [1]	**Baan SCS** [2]	**i2 Ryth**
Industry			
Aerospace	X	X	
Apparel & Footwear	X		
Automotive	X	X	X
Banking	X		
Chemicals	X		X
Construction	X	X	
Discrete Manufacturing	X	X	X
Education	X		
Energy	X		X

Financial Service	X		
Healthcare	X		X
High Technology	X	X	X
Media	X		
Oil & Gas	X		
Issuance	X		
Process Manufacturing	X		
Pharmaceutical	X		X
Retail	X		X
Telecommunication	X	X	
Transportation	X		X
Utility	X		
Ranking [4]	2	4	7
Product Design and Development			
Collaborative conceptual design			
Share design data on the web			

Design optimization	X		X
Support early supplier			X
involvement	X		X
Workflow enabling design			
process			

Supply Chain Planning

Supply chain design and	X	X	X
modeling			
Strategic optimization of	X	X	X
supply network			
Distribution and logistics	X	X	X
planning	X	X	X
Collaborative demand	X	X	X
planning			
Constraint-based	X	X	X
planning/scheduling	X	X	X
"What-if" simulation			
capability			

Graphical operational scheduling			
Order Life Cycle			
Available-to-Promise	X	X	X
Capable-to-Promise	X	X	X
Order configuration	X	X	X
Manufacturing execution	X (integrate with SAP	X (included in SCM solution)	X (includ SCM solu
Reactive planning/scheduling	ERP)	X	X
Delivery control	X	X	X
	X		

Analytics			
Sales			X
Procurement			X
Order fulfillment			X
Finance			
User Interface	Hybrid	Hybrid	Hyb
Enterprise modeling		X	

Workflow capability	X	X	X
Integration with B2B marketplace	X (with Commerce One)		X (with A
Integration with ERP	X (with SAP ERP)	X (with Baan ERP)	X

1. SAP (1999a, 1999b, 1999c, 1999d, 1999e, 2000)
2. Baan (2000a, 2000b)
3. i2 (2000a, 2000b, 2000c, 2000d, 2000e, 2000f)
4. Plant-Wide (2000)

All of the 3 solutions focus on the **supply chain** planning functionality. They all offer sophisticated planning engine which employs advanced planning algorithm likes mathematical programming (Irvin et al., **1999**), constraint programming(Ilog, 1998) and genetic algorithm. This functionality covers from strategic planning to operational planning. The SCM solutions also support **supply chain** execution. Since this function is

performed by traditional ERP system, the SCM vendors provide an integration interface

between the planning engine and other ERP systems. This can retain the legacy systems of a company to handle the order life cycle while improving the planning capability through the SCM solution. The SCM solutions offer integration facility with B2B marketplace. Like B2B solution, product design and development is also not well developed in SCM solution.

One of the under-developed area is rescheduling. The solutions provide simulation tool to analyze the changes in **supply chain** but few of them provides comprehensive rescheduling decision support and methodology. Since rescheduling decision is done in a real-time manner, quick response in **supply chain** does not allow the time consuming simulation or re-generation of optimization plan.

Analytic, like B2B marketplace, is an area that has not been fully exploited by SCM vendors. The 3 SCM solutions enable workflow automation in **supply chain**. Baan especially supports a comprehensive enterprise modeling. Wortmann et al. (2000) pointed out that such enterprise modeling functionality should be included in ERP system. Regarding to the user interface, the 3 solutions use both window-based and web-based interface. Window-based interface is used for design and transactional functions. For example, most of the interfaces of planning and execution functions are window-based. It is designed for internal use. Web-based interface is used for external purpose. For example, enquiry of available-to-promise (ATP), order tracking. Web-based interface also acts as an integrating point to B2B marketplace.

5. DISCUSSION OF COMPARISON

In this section, an overall discussion of academic research and commercial solutions in SCM will be presented. For the comparison of commercial solutions, Enterprise Resource Planning (ERP) systemis also included in this discussion. Since ERP is traditionally regarded as a solution to improve effectiveness and efficiency of business operations within a company, including ERP in the comparison will give a more complete view of the role of different software systems in **supply chain**. The selected functionalities aim at differentiating the core capability of each category of solution.

Table 3

Comparison of B2B, SCM and ERP

Functionality	B2B	SCM	ERP
Product Design and Development	Little	Growing concern	Integration w PDM packag
Supply Chain Planning and Optimization	Emerging feature	Core capability Generate an optimized plan for the whole **supply chain**	Optimize resources of a single compa

Order Life Cycle	Focus on item sourcing, order bidding and taking	Focus on execution and fulfillment of order	Core function Sales and marketing, purchasing,

			accounting an finance
Analytics	Great opportunity	Growing concern	Integration w business intelligence package
Business Services	Add-on capability	Not available	Not available
Scope of application	Extended Enterprise	Extended Enterprise	Single Enterp
User Interface	Near fully Web-based	Hybrid of Web-based and Window-based	Mainly Wind based

Based on the above comparisons (table 3), some of the research directions are obtained:

1. Integration of product design with production planning

From software comparison, both B2B and SCM lack development in this aspect. The difficulties are discussed in section 3. There have been a lot of academic researches in combining product design and production planning according to the concepts of concurrent engineering (Taylor, 1997; Garg, 1999; Graves and Willems; 2000b). Huang and Mak (2000) have developed a prototype to realize such integration on the

Internet. Much more research efforts are needed to investigate the mechanism of implementing such integration in reality.

2. Integration of **supply chain management** solution (SCM) and enterprise resource planning (ERP)

It is clear that integration of SCM and ERP is a promising trend. The focus of SCM is advanced planning across **supply chain** while the focus of ERP is on transactions handling during order execution and fulfillment. Many SCM vendors like i2 have already included execution functionalities like order entry in SCM package. Some

already included execution functionalities like order entry in SCM package. Some

traditional ERP vendors like SAP and Baan provide integration facility (e.g. application programming interface, API) for their SCM products. This trend indicates that SCM and ERP will finally merge together as a single solution.

3. Integration of **supply chain management** (SCM) solution and business-to-business (B2B) solution

As discussed in section 3, many B2B solution vendors are trying to integrate **supply chain** planning capability into the existing B2B solution. B2B solution focuses on early stage of order life cycle. For example, product content **management**, request for quotation, order bidding and acquisition and pricing. The B2B marketplace aims at matching buyer's need and supplier's capability. The **supply chain** planning process is still a developing feature in B2B marketplace. The B2B solution vendors can actually deploy the planning solution by integrating with SCM solution which is dedicated to optimization planning in **supply chain**. Since **supply chain** planning needs a lot of data

fromsupply **chain** partners . (Graves and Willems, 2000a; Sabri and Beamon, 2000; Lakhal et al., 2001), B2B marketplace can act as a **supply chain** data collection hub. Both buyer and supplier can share their plans on the web to facilitate **supply chain**

planning which aims at minimizing **supply chain** costs (Lee et al., 2000; Wei and Krajewski, 2000). There has been, however, a few literatures addressing the implementation issue of such integration. Although some SCM vendors offer initiatives in this aspect (SAP, 2000; Baan, 2000b), methodologies including theory and implementation are needed to optimize such **supply chain** integration.

4. User interface: full web-based vs. hybrid interface

Different solutions employ different type of interface. Traditional ERP system uses window-based interface. Newer systems like B2B and SCM use web page as an interface. The choice of interface depends on the content of application. Window-based interface is suitable for data entry form and click-and-drag function. Data entry function includes system setup, operation reporting (e.g. purchase order entry). One of the examples of Click-and-drag function is drawing and graphic application. Some design and modeling functions like enterprise modeling and **supply chain** design can be implemented in window-based interface. Since window-based application must be installed and operated on window-based computer or client, the application deployment is limited to single company or location. On the other hand, Web-based interface is suitable for distributed operation. Different users can access the application through the Internet/Intranet simultaneously. Therefore, web-based interface is extensively employed in B2B solution which facilitates customer and

supplier access product content and business transactions concurrently. In SCM solution, as planning function is the main feature, interface related to planning function is window-based. Web-based interface is used in customer and supplier interfacing.

5. Rescheduling in **supply chain**

Rescheduling is an undeveloped function in SCM solution. Some of the SCM solutions offer simulation tool which can evaluate different **supply chain** scenario in order to tackle disturbances in **supply chain** (SAP, 1999d). However, effective rescheduling solution requires very short computation time that may not be satisfied by simulation method. Although there have been some literatures of rescheduling, many of them tackle the problem in planning level (Shafaei and Brunn, 2000; Sabuncuoglu and Bayiz, 2000) instead of control level (Li et al., 2000; Jain and Elmaraghy, 1997). All of the literatures address the problem in a single enterprise. The impact of customer and supplier in rescheduling problem has not been discussed. Hence, there is a plenty room for this development in both commercial SCM solution and academic field.

6. CONCLUSION

This article reviewed literatures in three core processes (i.e. product design and development, **supply chain** planning and order life cycle) of **supply chain management**. Comparisons of business-to-business (B2B) solution and **supply chain management** (SCM) solution were presented in this article. The scope of comparison is limited to leading software vendors in the market. Three leading vendors are selected in B2B and SCM solution respectively. The comparison shows that B2B solution focuses on automation of business transactions between buyer and supplier like procurement, order bidding and acquisition and financial settlement while SCM solution focuses on optimization planning of **supply chain**. It is, therefore, concluded that B2B solution is used for order life cycle while SCM solution is used for **supply chain** planning. It is observed that vendors in both kinds of solutions are trying to integrate product design and development into their solutions. The results of comparison indicate that B2B solution can act as an integration interface between buyer and supplier. SCM solution can then make use of this venue to collect **supply chain** data for planning. By combining with the transactional capability of enterprise resource planning (ERP), it is believed that the three

types of solution, B2B, SCM and ERP, will integrate as a single solution to optimize the performance of the **supply chain**. The integration issue is, therefore, an important research area in **supply chain**. On the other hand, based on the results of comparisons, issue of rescheduling in **supply chain** is an under-developed area in both commercial solutions and academic research. Many literatures have tackled the problem at planning level but few of them study at control level. The issue includes decision support of rescheduling action, impact of customer and supplier of such decision and rescheduling

methodology of different disturbances in **supply chain**. It is concluded that a systematic rescheduling methodology is imperative to achieve a responsive and agile **supply chain**.

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APPENDIX

A1 Description of B2B solution vendors

A1.1 Ariba

Ariba provides four main solutions to B2B participants, namely Ariba Buyer, Ariba Marketplace, Ariba Dynamic Trade and Ariba Supplier. The buyer solution is

procurement automation. It aims at streamlining the whole procurement process of an enterprise. The supplier solution enables suppliers to connect to other marketplaces to seek business opportunity. It also supports content maintenance of suppliers' product. Marketplace maker solution helps market makers build up the B2B web site with transactions service. In addition to specific solution for buyer, supplier and market maker, Ariba also supports dynamic auction service to both buyers and suppliers.

A1.2 CommerceOne

Commerce One.net™ is an open e-marketplace that provides global e-commerce services to Buyers, Suppliers, and Net Market Makers. Commerce One.net is enabling a portfolio of e-commerce services for all trading partners to rapidly conduct business across e-marketplaces. It supports trade between buyers and suppliers across multiple e-marketplaces, is open to any application and technology standard and is an on-ramp to the Global Trading Web, the world's largest business-to-business trading community. Buyer can source product information in CommerceOne.net and find business partners. Buyer and supplier can meet together on the web and collaborate with each other.

CommerceOne offers trade services that facilitate the business processes. The services and solutions offered bv CommerceOne can be classified as: Enterprise Solution. Internet

Market Maker Solution, Supplier Services and Trading Services. Commerce One offers enterprise customers a comprehensive and interactive e-procurement solution. Through the Commerce One solution, comprised of Commerce One BuySite e-procurement application, and access to Commerce One's own e-marketplace, Commerce One.net, the entire procurement cycle from requisition to payment is completely automated. Information moves instantly from the user's desktop directly to the supplier's back office, with industry-leading XML technology.

Internet Market Makers Solutions

Commerce One offers solutions for Internet market makers in two categories: those who want to build open marketplaces and link them to other marketplaces, and those who want to create an Internet buying community of small- to medium-sized businesses or a select vertical industry. By creating a trading portal, market makers can extend their reach and take advantage of new ways to buy. Offers from many suppliers can be aggregated, or buyers and sellers can be matched in an exchange or auction. Operational efficiencies increase while costs decrease for all trading partners.

Supplier Services

Suppliers who join Commerce One.net have access to the world's largest business to business trading community. The benefits of being part of the community include the enhanced buyer relationships, global exposure to industry-leading buying organizations,

improved operating efficiency, and lower costs of content **management**.

Trading Services

Commerce One.net ensures that all transactive content (e.g. catalog content, pricing and availability) is accurate and up-to-date, and delivers robust trading partner application functionality including on-line order processing, exception handling, taxation, distribution, invoicing and payment. Commerce One.net also provides the environment for shared trading partner services such as spot buying, surplus disposition, bid & auction, RFP, RFQ and RFP processing and other various financial services.

A1.3 TradeMatrix

TradeMatrix offers six integrated services: Procurement, Commerce, Fulfillment, Planning, Product Development and Customer Care. These services are provided by a **supply chain management** (SCM) package developed by i2 (a detail comparison of SCM solution will be discussed in the next section). It also provides ability to connect multiple marketplaces so that user can do business with companies in other marketplace. TradeMatrix supports logistic tracking service that helps user provide accurate order information to its customer.

A2 Explanation of functionality in comparison B2B solutions

Functionality	Description
Industry	Indicates the industrythat can be supported by the solution.
Product Design and Development	Supports participation of trading partners in product design and development.
Supply Chain Planning	Provides planning functions for each level of planning.
Order Life Cycle	Supports order fulfillment.
Buyer Solution	Provides facility for buyer to search and request quotation of product and project proposal.
Supplier Solution	Enables connection to other potential buyer in the marketplace to do trading.

Marketplace Maker Solution	Helps marketplace makers to establish their own B2B site.
Business Service	Provides dynamic, real-time auction mechanisms such as reverse auction, dynamic pricing. Support logistics tracking, monitoring services
Analytics	Capability to analyze **supply chain** data.
Integration with ERP	Ability to integrate with existing ERP systems.
User Interface	How the solution is deployed.

A3 Description of SCM solution vendors

A3.1 SAP Advanced Planning Optimizer

SAP offers a series of modules in **supply chain management** solution called Advanced Planning Optimizer (APO). The modules cover all three levels of planning: strategic , tactical and operational. A brief description of the modules are presented in the following table.

Module	Description

Network Design	SAP APO Network Design supports tasks related to strategic planning, assignment and location placement as well as location selection decisions. It is a decision support tool which enables the user to solve strategic problems and carry out different strategic planning scenarios by planning the entire **supply chain** on an aggregated level.
Demand planning	It is a decision-support tool that allows user to perform what-if analysis and online simulation to create, store, and compare different planning versions.
Supply network planning and deployment	It helps user match purchasing, production and transportation processes to demand, and to balance and optimize your entire **supply** network. It provides all the tools to develop better plans and adapt them to the ever-changing business. It can also model an entire supply network with all constraints.

	The distribution network is optimized and balanced according to the algorithm.
Production Planning and	Its generate a capacity and material feasible plan in a single

Detailed Scheduling	pass Memory-based computing architecture. It employs the algorithm like theory of constraint to optimize all resources.
Global Available-to-Promise	This module uses a rules-based strategy to ensure manufacturer can deliver what it promises to its customers.
Transportation Planning and Vehicle Scheduling	This modules enables a planner to schedule and route vehicles, optimize loads and select the right carrier. The Vehicle Scheduling component addresses pickup and delivery problems like round trip / multi-pick / multi-drop management. The Transportation Planning component finds the best route that a vehicle should follow through a network of roads, rail lanes, shipping lanes or air navigational routes.
Collaborative Planning	It helps enterprises carry out collaborative supply chain planning activities with their business partners. Thus, relevant input from business partners can be taken into account to synchronize planning across the network.

A3.2 Baan Supply Chain Solutions (SCS)

Baan also offers a set of **supply chain management** tools for optimization planning. The solution covers both planning and execution in **supply chain**. A brief introduction to the solutions is presented in the following table.

Strategic **supply chain** design	The solution helps user prepare for and take strategic **supply chain** infrastructure decisions; as well as solving **supply chain** problems involving Constraint Modeling across a complex network of material suppliers, manufacturing facilities, distribution centers and customers in order to develop an optimal **supply chain** plan.
Demand **Management**	It is used to forecast demand for events, promotions, and new product releases. The module is capable of analyzing and modeling thousands of different demand patterns.
The **Supply Chain** Planning and Order Fulfillment	This solution lets companies continuously synchronize manufacturing and distribution activities with the pull of customer demand. It supports real-time order promising to customer.
Factory Scheduling and execution	It provides feasible and optimized operating schedules for each resource in the plant to synchronize production planning when sudden changes in market demand and plant floor conditions occur. Manufacturing execution provides manufacturers with operational visibility necessary for control of manufacturing

	activities.
Logistic Planning	It helps user decide the optimized transportation means by

	combining transportation and delivery needs, geographical data and service providers' information,

A3.3 i2 technology

i2 offers six integrated solutions that cover most of the business processes within and outside the company.

Modules	Description
Design	This solution focuses on maximizing revenue, market share, and product margins by optimizing product mix and lifecycle management decisions. It allows companies to collaborate at a strategic level to optimize resource allocations across multiple projects. It targets new product development costs, eliminating redundant parts and suppliers and decreasing cost of goods sold. It also provides a secure, easy-to-use, web-based collaboration platform for extended program and

	design collaboration in a marketplace environment.
Plan	This solution concurrently considers demand, materials, and capacities through the following business processes: Strategic Planning, Demand Planning, **Supply** Planning and Scheduling.
Sell	This solution consists of four functions: Market, Sell, Fulfill and Care.

	Market: data analytics, customer profile **management**
	Sell: Match demand based on company's objectives/resources, RFQ by buyer, product configuration, personalized product catalog, payment processing
	Fulfill: Order promising, order monitoring to alerting
	Care: sales return, handle problem service
Buy	**Buy solution consists of Source, Negotiate, Plan and Order.**
	Source: To analyze commodities, suppliers, and contract performance and create optimal commodity groupings, identify potential sources of **supply**, and rationalize the

component base,

Negotiate: To create quotations and negotiate appropriate purchasing contracts.

Plan: To leverage supplier collaboration for greater accuracy and efficiency,

Order: To facilitate the actual purchasing transaction

Fulfill	Fulfill solution helps fulfillment professionals perform two key tasks: make accurate promises to their customers, and then deliver on those promises.
Service	Service solution contains three main product modules: Service Asset Manager, Service Scheduling, and MRO. Service Asset Manager plans the parts inventories and

replenishments required for maintenance and overhaul of equipment and facilities. Service Scheduling is a decision-support capability for dispatching service work crews. And MRO is a procurement tool that enables buyers to find sources for needed parts rapidly and select the supplier with

the most favorable offering

A4 Description of functionality in comparison of SCM solutions

Functionality	*Description*
Industry	Indicates the industry that can be supported by the solution.
Ranking	Ranking is based on revenue derived from manufacturing software in the calendar year 1999.
Product design and development	Supports participation of trading partners in product design and development.
Supply chain planning	Provides planning functions for each level of planning.
Order Life Cycle	Supports order fulfillment.
Analytics	Capability to analyze supply chain data.
User Interface	Web-based or window-based
Enterprise modeling	Model the business process in supply chain
Workflow capability	Provide workflow feature to automate supply

	chain process
Integration with B2B marketplace	Ability to integrate with B2B
Integration with ERP	Ability to integrate with other ERP